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Kawasaki et al.

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(54) **ELECTRON DEVICE TESTING APPARATUS HAVING HIGH CURRENT AND LOW CURRENT TESTING FEATURES**

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(51) **Int. Cl.**[7] **G01R 31/28**
(52) **U.S. Cl.** **324/158.1**; 324/765
(58) **Field of Search** 324/73.1, 763, 324/765, 158.1; 714/724, 736

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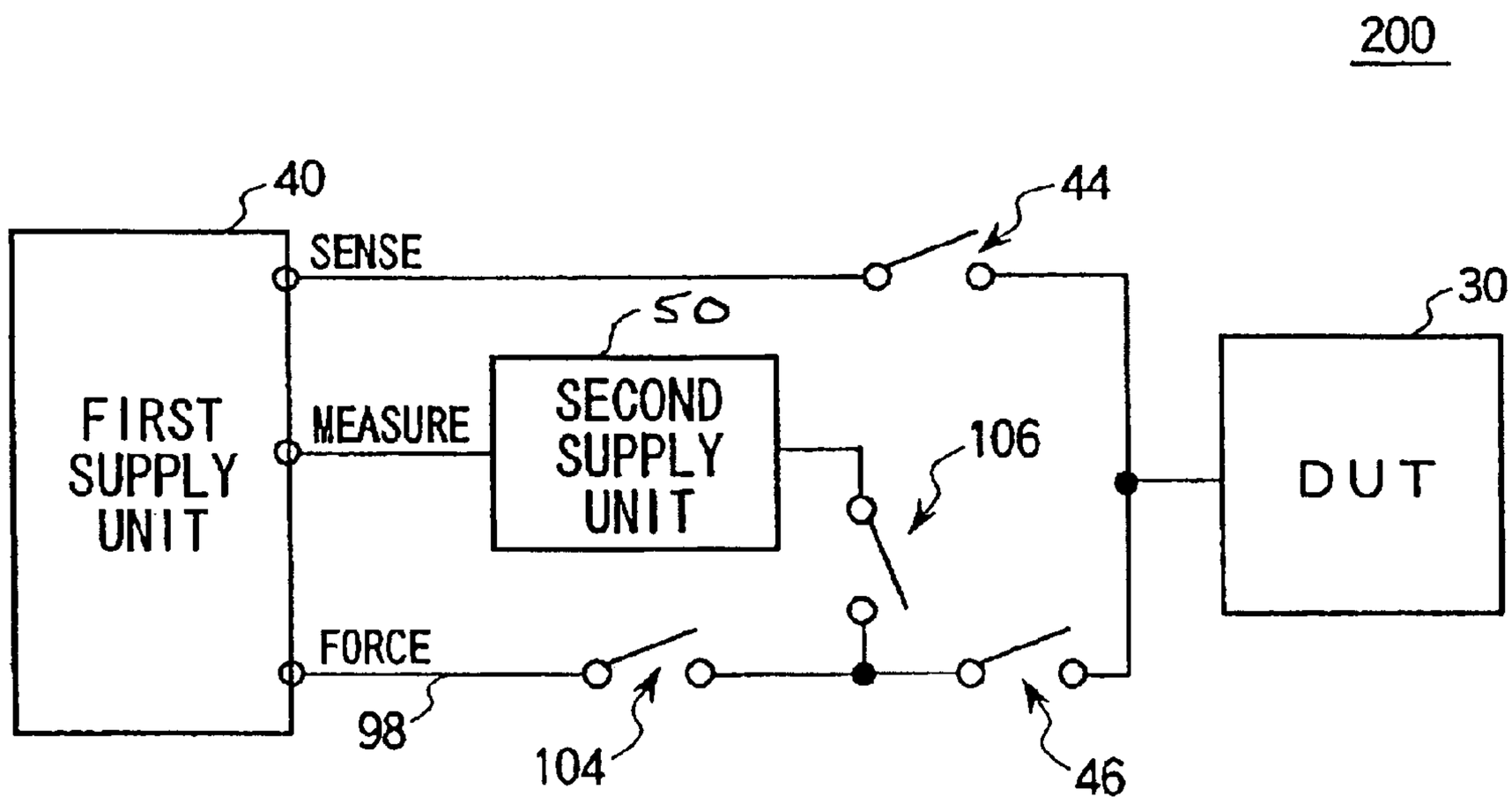
(57) **ABSTRACT**

A testing apparatus for testing an electron device, has a first supply unit that supplies a first current to the electron device; a first feedback circuit which feeds back voltage applied to the electron device to the, first supply unit; a first switch which switches to whether or not connect electrically the electron device to the first feedback circuit; a second supply unit that supplies a second current to the electron device, the second supply unit being separated from the electron device by the first switch.

2 Claims, 3 Drawing Sheets



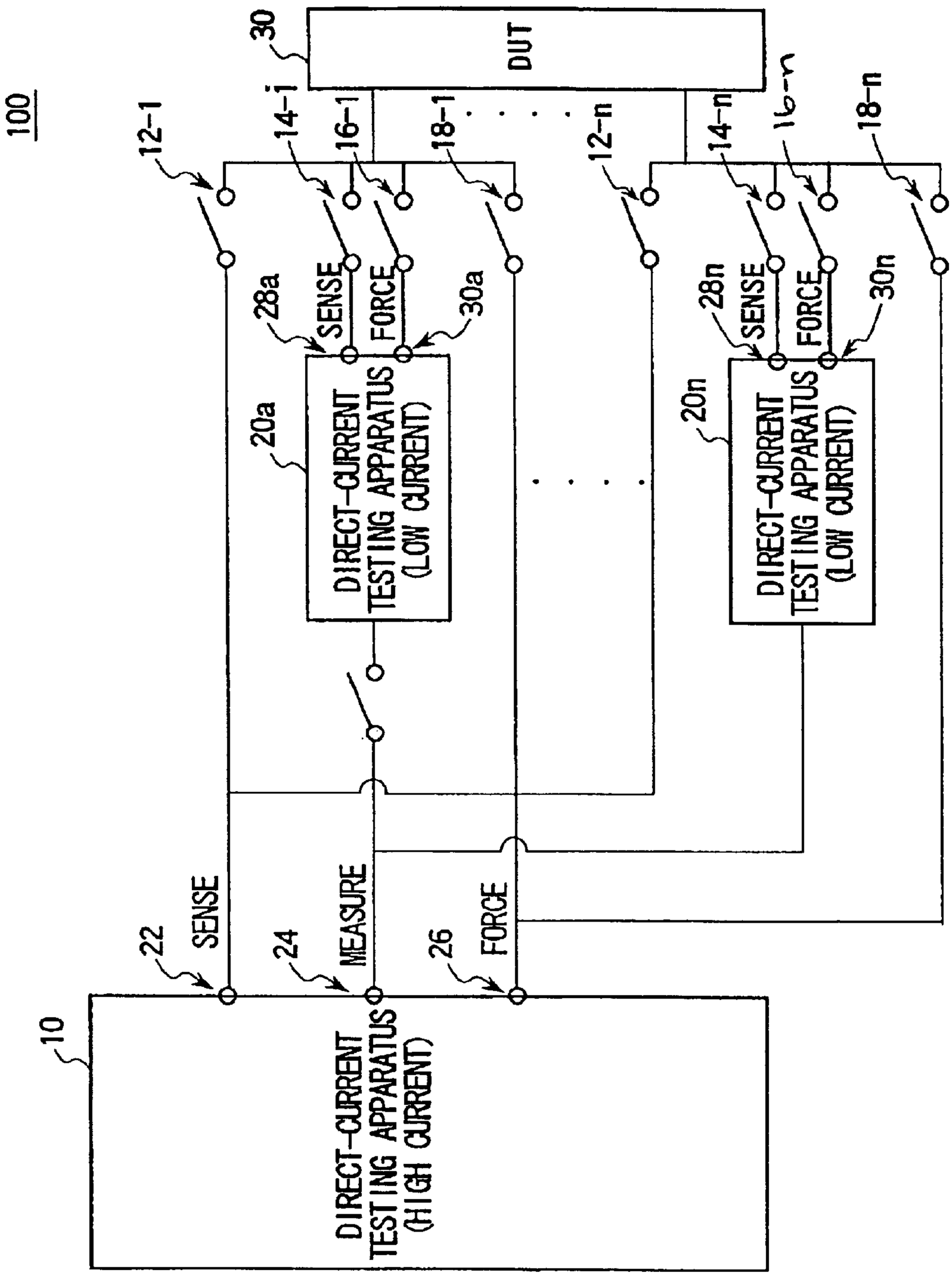

100
30
DUT
12-1
14-i
16-1
18-1
12-n
14-n
16-n
18-n
28a
SENSE
FORCE
30a
20a
DIRECT-CURRENT TESTING APPARATUS (LOW CURRENT)
28n
SENSE
FORCE
30n
20n
DIRECT-CURRENT TESTING APPARATUS (LOW CURRENT)
22
SENSE
24
MEASURE
26
FORCE
10
DIRECT-CURRENT TESTING APPARATUS (HIGH CURRENT)

FIG. 1

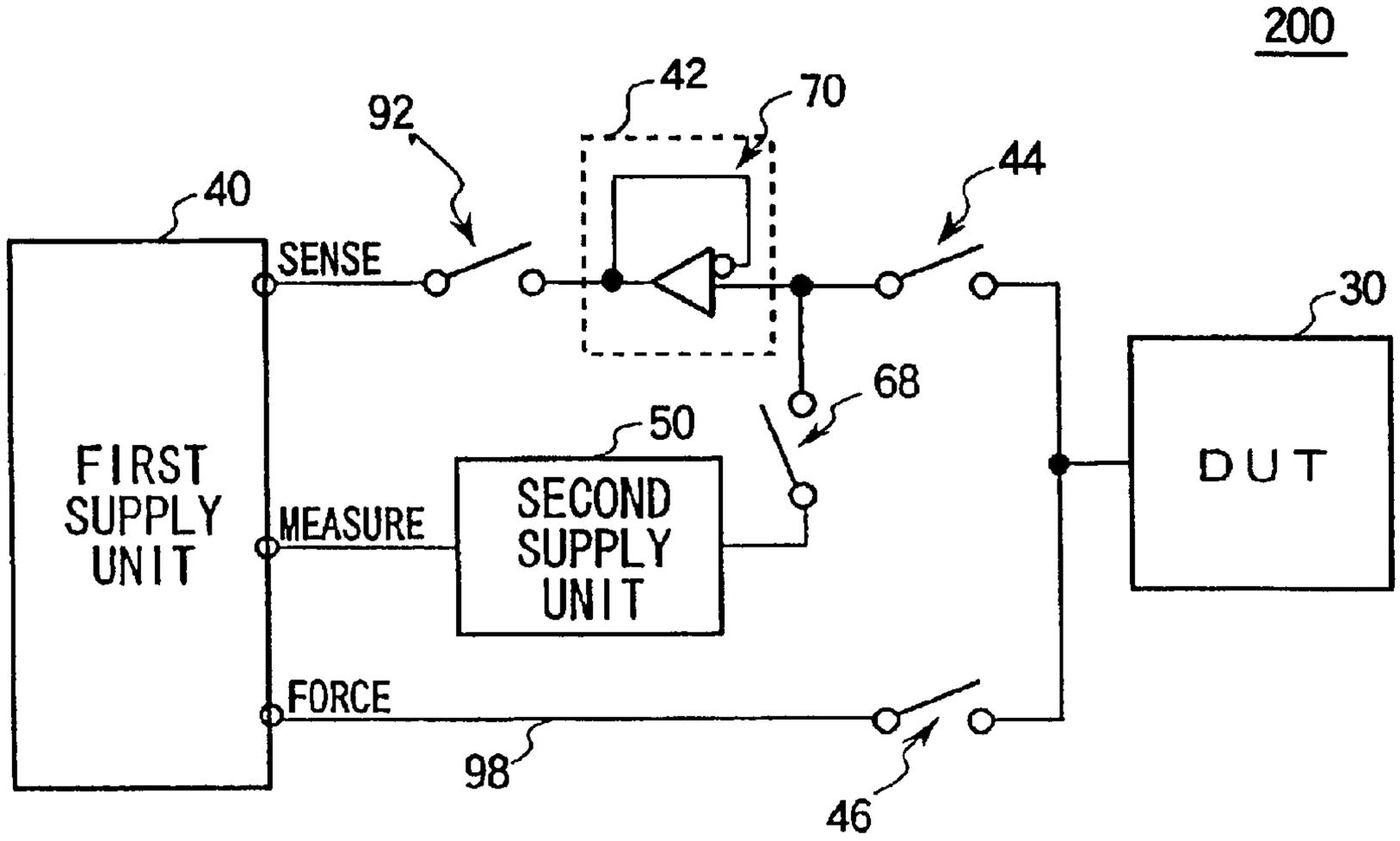

200
42
70
92
44
40
SENSE
30
68
50
FIRST SUPPLY UNIT
MEASURE
SECOND SUPPLY UNIT
DUT
FORCE
98
46

FIG. 2A

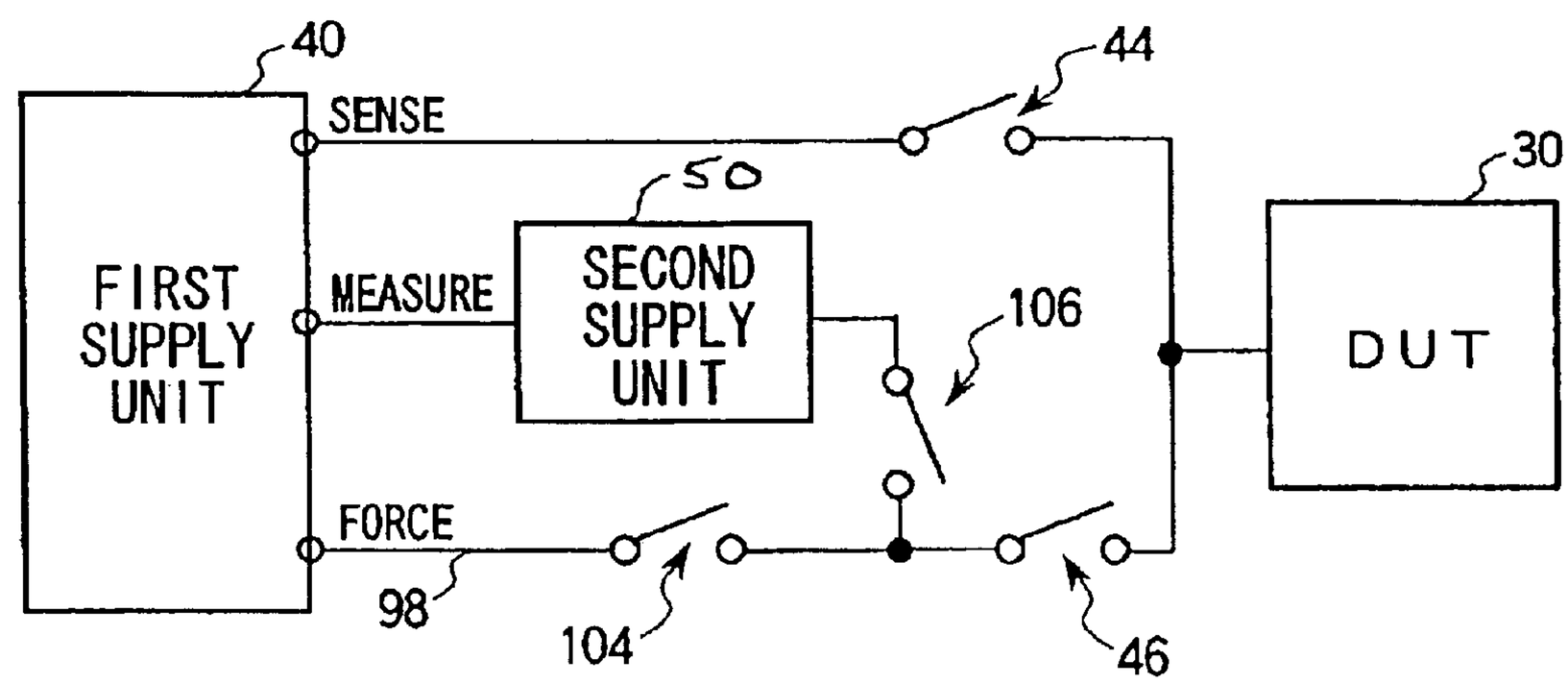

200
40
44
SENSE
50
30
FIRST SUPPLY UNIT
MEASURE
SECOND SUPPLY UNIT
106
DUT
FORCE
98
104
46

FIG. 2B

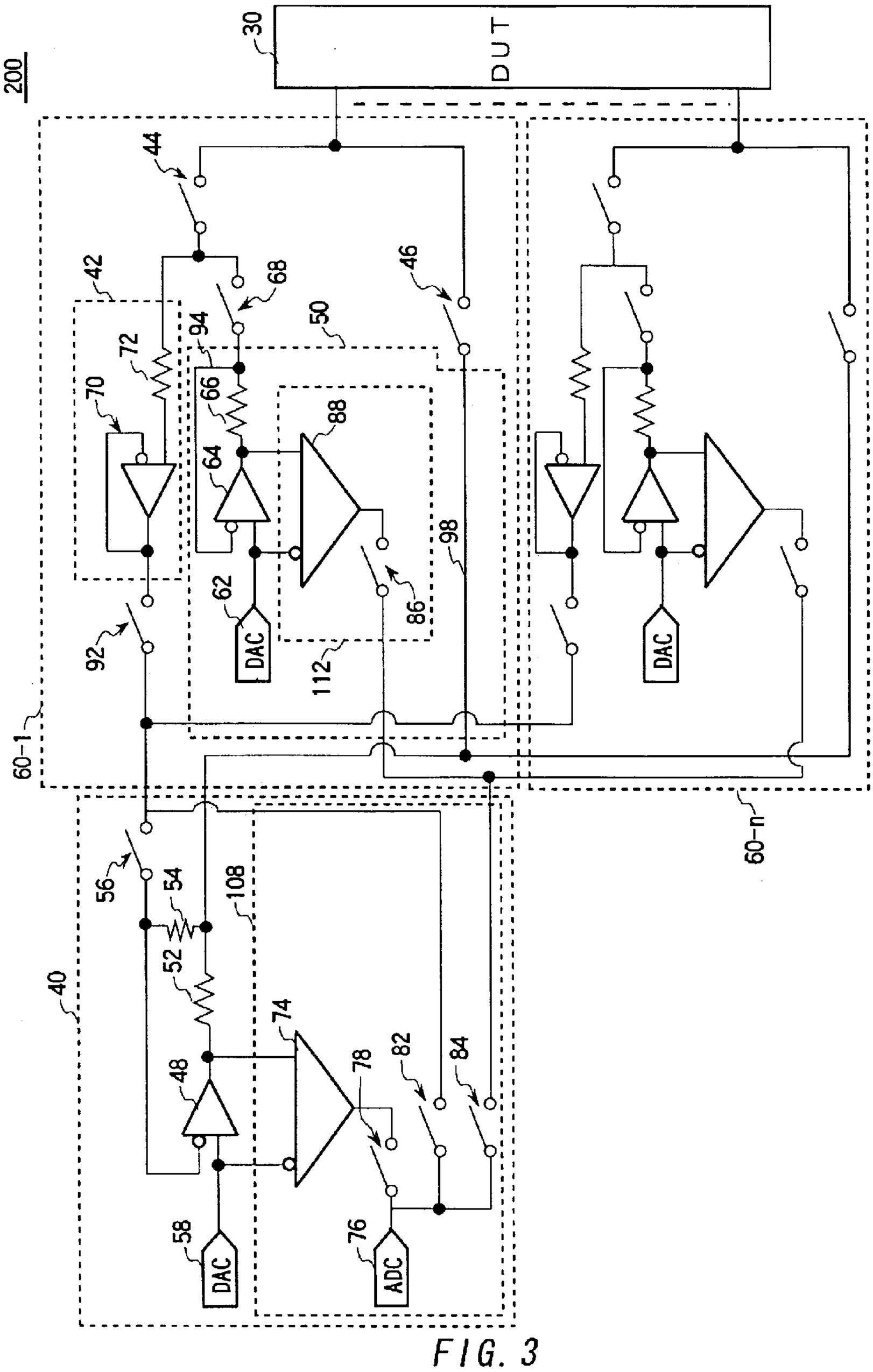

200
30
DUT
44
42
68
46
50
94
72
70
66
64
88
62
DAC
86
92
98
112
60-1
60-n
56
54
108
52
40
48
74
78
82
84
58
DAC
76
ADC

FIG. 3

ELECTRON DEVICE TESTING APPARATUS HAVING HIGH CURRENT AND LOW CURRENT TESTING FEATURES

This application is con of PCT/JP01/06324 filed Jul. 23, 2001.

This patent application claims priority based on a Japanese patent application, 2000-222926 filed on Jul. 24, 2000, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a testing apparatus for testing an electron device. More particularly, the present invention relates to a testing apparatus, which has an apparatus for a high current testing, and an apparatus for a low current testing.

2. Description of the Related Art

FIG. **1** shows a conventional testing apparatus **100**. The testing apparatus **100** comprises a direct-current testing apparatus **10** for a high current and one or more direct-current testing apparatus **20***a* . . . **20***n* for a low current. The direct-current testing apparatus **10** is an apparatus, which supplies higher current than the direct-current testing apparatus **20***a* . . . **20***n*. The electron device **30** to be tested has a plurality of electrodes, each of which is connected to corresponding switches **12-1** . . . **12**-*n*, switches **14-1** . . . **14**-*n*, switches **16-1** . . . **16**-*n*, switches **18-1** . . . **18**-*n*. Switches **12-1** . . . **12**-*n* and **18-1** . . . **18**-*n* are each connected to a sense line **22** and a force line **26** of the direct-current testing apparatus **10**. As shown in FIG. **1**, switches **14-1** . . . **14**-*n* are each connected to corresponding sense lines **28***a* . . . **28***n* of the direct-current testing apparatus **20***a* . . . **20***n* and switches **16-1** . . . **16**-*n* are each connected to corresponding force lines **30***a* . . . **30***n* of the direct-current testing apparatus **20***a* . . . **20***n*. Further, the testing apparatus **100** has a measure line **24** selectively connecting the direct-current testing apparatus **10** and direct-current testing apparatus **20***a* . . . **20***n*.

The testing apparatus **100** performs a voltage applying current measuring test, which applies predetermined voltage on an electron device **30** to measure a current supplied to the electron device **30**, or performing an electric current applying voltage measuring test, which supplies predetermined electric current to the electron device **30** to measure a voltage applied on the electron device **30**.

The testing apparatus **100** will be explained below using a voltage applying current measuring test as an example. When a high current must be supplied to the electron device **30**, the direct-current testing apparatus **10** applies voltage to the electron device **30** through the force line **26**. The voltage applied to the electron device **30** is fed back to the direct-current testing apparatus **10** through the sense line **22**. The direct-current testing apparatus **10** adjusts the voltage applied to the electron device **30** to the predetermined voltage based on the fed-back voltage. Moreover, the direct-current testing apparatus **10** detects the current supplied to the electron device **30** when predetermined voltage is applied to the electron device **30**. The testing apparatus **100** judges the quality of an electron device **30** based on the detected current.

When a low current must be supplied to the electron device **30**, the direct-current testing apparatus **20***a* . . . **20***n* applies voltage to the electron device **30**. The voltage applied to the electron device **30** is fed back to the direct-current testing apparatus **20***a* . . . **20***n*. The direct-current testing apparatus **20***a* . . . **20***n* adjusts the voltage applied to the electron device **30** to predetermined voltage based on the fed-back voltage. Moreover, the direct-current testing apparatus **20***a* . . . **20***n* detects the current supplied to the electron device **30** when predetermined voltage is applied to the electron device **30**. The testing apparatus **100** judges the quality of an electron device **30** based on the detected current.

When the testing is performed by applying voltage to the electron device **30** from the direct-current testing apparatus **10**, the corresponding switches **12-1** . . . **12**-*n* and **18-1** . . . **18**-*n* are switched-on, and the switches **14-1** . . . **14**-*n* and **16-1** . . . **16**-*n* are switched-off. When the testing is performed by applying voltage to the electron device **30** from the direct-current testing apparatus **20***a* . . . **20***n*, the corresponding switches **14-1** . . . **14**-*n* and **16-1** . . . **16**-*n* are switched-on and the switches **12-1** . . . **12**-*n* and **18-1** . . . **18**-*n* are switched-off.

The electron device **30** has a plurality of electrodes to be tested, and the testing apparatus **100** has the direct-current testing apparatuses **20** for each electrode. The testing apparatus **100** performs testing by choosing the desired electrodes using the switches **12-1** to **12**-*n*, the switches **14-1** to **14**-*n*, the switches **16-1** to **16**-*n*, and the switches **18-1** to **18**-*n*, which are provided for each plurality of electrodes. Moreover, the testing apparatuses that perform other tests are also connected to the plurality of the electrodes of the electron device **30**.

The testing apparatus **100** mentioned above switches-off switches **12-1** . . . **12**-n, when the testing apparatus **100** is separated from the electron device **30**. Each of the switches has a floating capacity, called off capacity. Since the off capacity is large, the value measured by the testing apparatus that performs other test is affected when the switches **12-1** . . . **12**-*n*, **14-1** . . . **12**-*n*, **16-1** . . . **12**-*n* and **18-1** . . . **12**-*n* are switched-off. Thus, it was difficult to test the electron device **30** with sufficient accuracy. Therefore, it was desired to reduce the off capacity of the switch that separates the testing apparatus **100** and the electron device **30**.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a testing apparatus which overcomes the above issues in the related art. This object is achieved by combinations described in the independent claims. The dependent claims define further advantageous and exemplary combinations of the present invention.

To solve the above issues, according to the first aspect of the present invention, a testing apparatus for testing an electron device comprises a first supply unit that supplies a first current to the electron device; a first feedback circuit which feeds back voltage applied to the electron device to the first supply unit; a first switch which switches to whether or not connect electrically the electron device to the first feedback circuit; and a second supply unit that supplies a second current to the electron device, the second supply unit being separated from the electron device by the first switch.

In the first aspect of the present invention, the first supply unit may adjust a voltage or a current to be supplied to the electron device based on the voltage, which is fed back by the first feedback circuit. Moreover, the testing apparatus may further comprise a second switch that switches to whether or not connect electrically the first supply unit to the electron device. The testing apparatus may further comprise: a third switch that selects to whether or not connect electrically the first feedback circuit to the first supply unit; and

a fourth switch that selects to whether or not connect electrically the second supply unit to the electron device via the first switch. The second current may be lower than the first current.

The first feedback circuit may have a voltage follower circuit that outputs a voltage substantially equal to an input voltage, and the input impedance of the voltage follower circuit is higher than the output impedance of the voltage follower circuit. The second supply unit may have a supply source that supplies the second current to the electron device and a feedback path that feeds back the voltage applied to the electron device to the supply source; and the supply source adjusts the voltage or current to be output to the electron device based on the voltage fed back by the feedback path.

The electron device may have a plurality of electrodes; and the first supply unit may supply the first current to each plurality of electrodes; and the testing apparatus may further comprise: a plurality of the first feedback circuits, each of which feeds back voltage applied to the plurality of electrodes to the first supply unit, respectively; a plurality of the first switches, each of which switches to whether or not connect electrically the plurality of electrodes to the plurality of first feedback circuits; and a plurality of second supply units, each of which supplies a second current, which is lower than a current that is supplied by the first supply unit, to each of the plurality of electrodes, and the plurality of second supply units are separated from the plurality of electrodes by the plurality of the first switches, respectively. The testing apparatus may further comprising a judging unit that judges quality of the electron device based on the detected voltage or current supplied to the electron device detected by one of the first supply unit and a plurality of the second supply units.

According to the second aspect of the present invention, a testing apparatus for testing an electron device comprises: a first supply unit that supplies a first current to the electron device; a supply line that connects electrically the electron device and the first supply unit, and the first current flowing therethrough; a first feedback circuit which feeds back voltage applied to the electron device to the first supply unit; a second switch provided on the supply line which switches to whether or not connect electrically the electron device and the first supply unit; and a second supply unit that supplies a second current to the electron device, the second supply unit being separated from the electron device by the second switch.

The testing apparatus may further comprise: a fifth switch that selects to whether or not connect electrically the first supply unit to the electron device via the second switch; and a sixth switch that selects to whether or not connect electrically the second supply unit to the electron device via the second switch. The second current may be lower than the first current.

The electron device may have a plurality of electrodes; and the testing apparatus further comprising: a plurality of the supply line that connects electrically the electron device and the first supply unit, and the first current, which is supplied to each of the plurality of electrodes by the first supply unit, flowing therethrough; and a plurality of first feedback circuits, each of which feeds back voltage applied to the plurality of electrodes to the first supply unit, respectively; a plurality of the second switches provided on the supply line, each of which switches to whether or not connect electrically the plurality of electrodes to the first supply unit; and a plurality of the second supply units, each of which supplies a second current, which is lower than the current that is supplied by the first supply unit, to the plurality of electrodes, and the second supply units are separated from the plurality of electrodes by the plurality of second switches.

This summary of the invention does not necessarily describe all necessary features of the present invention. The present invention may also be a sub-combination of the above described features. The above and other-features and advantages of the present invention will become more apparent from the following description of embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a configuration of a conventional testing apparatus **100**.

FIGS. **2**A and **2**B show examples of the configuration of a testing apparatus **200** in the present embodiment.

FIG. **3** shows an example of the circuit configuration of the testing apparatus **200** shown in FIG. **2**A.

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described based on the preferred embodiments, which do not intend to limit the scope of the present invention, but exemplify the invention. All of the features and the combinations thereof described in the embodiment are not necessarily essential to the invention.

FIGS. **2**A and **2**B show examples of the configuration of a testing apparatus **200** in the present embodiment. The testing apparatus **200** comprises a first supply unit **40**, a second supply unit **50**, a first feedback circuit **42**, a switch **44**, a switch **46**, a switch **68**, a switch **92**, and a supply line **98**. The first supply unit **40** supplies a first current to an electron device **30**, and the second supply unit **50** supplies a second current, which is lower than the first current.

The first feedback circuit **42** feeds back the voltage applied to the electron device **30** to the first supply unit **40**. The switch **44** switches to whether or not connect electrically the first feedback circuit **42** to the electron device **30**. Moreover, the second supply unit **50** is separated from the electron device **30** by the first switch **44**.

The switch **46** is provided on the supply line **98** that connects electrically the electron device **30** and the first supply unit **40**. The first current, which is supplied by the first supply unit **40**, is flowing through the switch **46**. The switch **46** switches to whether or not connect electrically the first supply unit **40** and the electron device **30**. The switch **92** switches to whether or not connect the first supply unit **40** to the first feedback circuit **42**. The switch **68** selects to whether or not connect electrically the second supply unit **50** to the electron device **30** via the switch **44**.

Moreover, although the second supply unit **50** is connected to the electron device **30** via the switch **44** in this example, the second supply unit **50** may be connected to the electron device **30** via the switch **46** as shown in FIG. **2**B.

FIG. **2**B shows another embodiment of the testing apparatus **200**. The testing apparatus **200** comprises a first supply unit **40**, a supply line **98**, a switch **44**, a switch **46**, and a second supply unit **50**. The element shown in FIG. **2**B, which has the may have the same or similar functions and configurations with that of the element shown in FIG. **2**A.

The second supply unit **50** is connected to the electron device **30** via the switch **46**. A switch **104** selects to whether or not connect electrically the first supply unit **40** to the

electron device **30** via the switch **46**. A switch **106** selects to whether or not connect electrically the second supply unit **50** to the electron device **30** via the switch **46**.

FIG. **3** shows an example of the circuit configuration of the testing apparatus **200** shown in FIG. **2**A. The testing apparatus **200** comprises the first supply unit **40**, the second supply unit **50**, the first feedback circuit **42**, the switch **44**, the switch **46**, the supply line **98**, the switch **68**, and the switch **92**.

The element shown in FIG. **3**, which has the same reference numeral with the reference numeral of the elements shown in FIG. **2**A, may have the same or similar functions and configurations with that of the element shown in FIG. **2**A.

The testing apparatus **200** performs the voltage applying current measuring test, which applies a predetermined voltage to the electron device **30** and detects the current which is supplied to the electron device **30**, and the current applying voltage measuring test, which supply a predetermined current to the electron device **30** and detects the voltage that is applied to the electron device **30**. The testing apparatus **200** is explained below using the case where the voltage applying current measuring test is performed.

The first supply unit **40** has a voltage generating unit **58**, which generates voltage, a voltage adjustment unit **48**, which adjusts voltage, a resistor **52**, a resistor **54**, a switch **56**, and a first detection unit **108**. The first supply unit **40** is connected to the electron device **30** via the switch **46**. The first supply unit **40** applies voltage to the electron device **30**. The voltage applied to the electron device **30** is fed back to the first supply unit **40** through the first feedback circuit **42**. The first supply unit **40** adjusts the voltage, which is to be applied to the electron device **30**, to a predetermined voltage based on the fed-back voltage. Moreover, when the current applying voltage measuring test is performed, the first supply unit adjusts the current supplied to the electron device **30** to predetermined current.

The voltage generating unit **58** may be a digital analog converter (DAC), to which predetermined voltage value is provided by the digital signal, that converts the provided digital signal to an analog signal. The voltage generating unit **58** applies the voltage, which is based on the provided voltage value, to the electron device **30** through the voltage adjustment unit **48**, the resistor **52**, and the switch **46**.

The voltage adjustment unit **48** applies the voltage, which is based on the voltage fed back by the first feedback circuit **42**, to the electron device **30** through the resistor **52** and the second switch **46**. That is, the voltage adjustment unit **48** applies the voltage to the resistor **52** so that the voltage, which is generated by the voltage generating unit **58**, becomes equal to the voltage, which is applied to the electron device **30**. The voltage adjustment unit **48** may be an amplifier, for example.

The first detection unit **108** has a detection unit **74**, a converter **76**, a switch **78**, a switch **82**, and a switch **84**. The first detection unit **108** detects the current supplied to the electron device **30** when the first supply unit **40** applies predetermined voltage to the electron device **30**.

The detection unit **74** detects the value of the current, which is supplied to the electron device **30** by the first supply unit **40**. The detection unit **74** detects the value of the current, which flows to the resistor **52** of the first supply unit **40**. That is, the detection unit **74** detects the amount of voltage drop in the resistor **52** by detecting the difference between the input voltage and the output voltage of the adjustment unit **48**. Since the resistance of the resistor **52** is known, a current value is calculated from the amount of voltage drop.

The detection unit **74** provides the detected amount of voltage drop to the converter **76** through the switch **78**. The converter **76** may be an analog digital converter (ADC) that converts analog data to digital data. The converter **76** converts the provided amount of voltage drop to digital data. The testing apparatus **200** may have a judging unit which judges the quality of the electron device based on the digital data converted by the converter **76**.

In this example, the first detection unit **108** detects the current value supplied to the electron device **30**. When the current applying voltage measuring test is performed, the first detection unit **108** may detect the voltage value applied to the electron device **30**.

The first feedback circuit **42** may have a voltage follower circuit **70** which outputs voltage substantially equal to the input voltage. The input impedance of the first feedback circuit **42** is higher than the output impedance the first feedback circuit **42**. The voltage follower circuit **70** may have an amplifier, for example. The voltage follower circuit **70** may have an amplifier, the input impedance of which is substantially infinite or sufficiently higher than the impedance of surrounding circuits, and the output impedance of which is substantially zero, and the gain of which is sufficiently high.

The switch **92** selects to whether or not connect electrically the first feedback circuit **42** to the first supply unit **40**. The switch **68** selects to whether or not connect electrically the second supply unit **50** to the electron device **30** via the switch **44**.

The second supply unit **50** has a supply source that supplies the second current to the electron device **30**, a feedback path **94** that feeds back the voltage, which is applied to the electron device **30**, to the supply source, a resistor **66**, and a second detection unit **112**. The second supply unit **50** is connected to the electron device **30** via the first switch **44**. The second supply unit **50** applies the predetermined voltage to the electron device **30**.

The supply source has the voltage generating unit **62**, which generates voltage, and the voltage adjustment unit **64**, which adjusts voltage. The voltage generating unit **62** may be a digital analog converter, to which the predetermined voltage value is provided by the digital signal, that converts the provided digital signal to an analog signal. The voltage generating unit **62** applies the voltage, which is based on the provided voltage value, to the electron device **30** through the voltage adjustment unit **64**, the resistor **66**, the switch **68**, and the first switch **44**.

The voltage adjustment unit **64** applies the voltage, which is based on the voltage fed back by the feedback path **94** to the electron device **30** through the resistor **66**, the switch **68**, and the first switch **44**. That is, the voltage adjustment unit **64** applies the voltage to the resistor **66** so that the voltage, which is generated by the voltage generating unit **62**, and the voltage, which is applied to the electron device **30**, become equal. The voltage adjustment unit **64** may be an amplifier, for example.

The supply source may change the voltage or current supplied to the electron device **30** based on the voltage fed back by the feedback path **94**. In case of the voltage applying current measuring test, the supply source adjusts the voltage, which is to be supplied to the electron device **30**, to the predetermined voltage based on the fed-back voltage. Moreover, when the current applying voltage measuring test is performed, the supply source adjusts the current, which is to be supplied to the electron device **30**, to a predetermined current.

The second detection unit **112** has a detection unit **88** and a switch **86**. The detection unit **88** detects the current value, which is supplied to the electron device **30** by the second supply unit **50**. The detection unit **88** detects the current value which flows to the resistor **66** of the second supply unit **50**. That is, the detection unit **88** detects the amount of voltage drop in the resistor **66** by detecting the difference of the input voltage and the output voltage of the adjustment unit **64**. Since the resistance of the resistor **66** is known, a current value is calculated from the amount of the voltage drop. The detection unit **88** provides the detected amount of voltage drop to the converter **76** of the first detection unit through the switch **86** and the switch **84**.

When high current is supplied to the electron device **30**, predetermined voltage is applied to the electron device **30** from the first supply unit **40** by short-circuiting the switch **46**, the switch **44**, the switch **92**, and the switch **56**. When a low current is supplied to the electron device **30**, a predetermined voltage is applied to the electron device **30** from the second supply unit **50** by short-circuiting the switch **68** and the switch **44**.

If the electron device **30** has a plurality of electrodes to be tested, the testing apparatus **200** may have a plurality of testing units (from **60-1** to **60-*n***) corresponding to each of the plurality of the electrodes where "n" is a natural number. Each of the plurality of testing units **60-1** . . . **16-*n*** may have the same configuration and the same function, respectively. For example, as shown in FIG. **3**, the testing unit **60-1** has the second supply unit **50**, the first feedback circuit **42**, the switch **44**, the switch **46**, the switch **92**, and the switch **68**.

Each of the elements of the testing unit **60-1** has the configuration and the function, which is explained in relation with FIG. **3**. Other testing units **60-1** . . . **16-*n*** may have the same or similar configuration and function with that of the testing unit **60-1**. The first supply unit **40** supplies the first current to each of the plurality of electrodes of the electron device **30**. Each of the first feedback circuits **42** of the testing unit **60** feeds back the voltage applied to the plurality of the electrodes to the first supply unit, respectively. Each of the switches **44** of the testing unit **60** switches to whether or not connect electrically the plurality electrodes to the plurality first feedback circuits **42**.

Each of the second supply units **50** of the testing unit **60-1** . . . **16-*n*** is separated from the plurality of electrodes by the plurality of switches **44**. Each of the second supply units **50** supplies the second current, which is lower than the current that is supplied by the first supply unit **40**, to the plurality of electrodes, respectively. The second current provided by the plurality of second supply units **50** may have different values, respectively.

Moreover, the detection unit **74** of the first detection unit **108** may generate digital data based on the current value, which is detected by the first detection unit **108** or the second detection units **112** included in one of the first supply units **40** or the plurality of second supply units **50**. The switch **78**, the switch **84**, and the plurality of switches **86** included in the plurality of testing units **60-1** . . . **16-*n*** select the current values detected by the detection units to be converted to digital data.

In FIG. **3**, the example in which the second supply unit **50** is electrically connected to the electron device **30** via the switch **44** was explained. However, as explained in FIG. **2**B, the second supply unit **50** may be connected electrically to the electron device **30** via the switch **46** as other examples.

Moreover, in this example, the second supply unit **50** supplies the current, which is lower than the current that is supplied by the first supply unit **40**. However, the second supply unit **50** may supply the current, which is higher than the current that is supplied by the first supply unit **40** as other examples.

According to the testing apparatus **200** in the present embodiments explained above, the number of the switches for separating the testing apparatus **200** from the electron device **30** can be reduced compared with the conventional testing apparatus. Therefore, the off capacity of a switch can be reduced so that it becomes possible to perform accurate testing.

As clear from the above explanation, according to the present embodiment, it becomes possible to reduce the off capacity of the switch for separating the testing apparatus **200**. Therefore, it becomes possible to test an electron device **30** with better accuracy.

Although the present invention has been described by way of exemplary embodiments, it should be understood that many changes and substitutions may be made by those skilled in the art without departing from the spirit and the scope of the present invention which is defined only by the appended claims.

What is claimed is:

1. A testing apparatus for testing an electron device, comprising:

a first supply unit that supplies a first current to said electron device;

a supply line that connects electrically said electron device and said first supply unit, and said first current flowing therethrough;

a first switch provided on said supply line which switches to whether or not connect electrically said electron device and said first supply unit;

a second supply unit that supplies a second current to said electron device, said second supply unit being separated from said electron device by said first switch;

a second switch that selects to whether or not connect electrically said first supply unit to said electron device via said first switch; and

a third switch that selects to whether or not connect electrically said second supply unit to said electron device via said first switch.

2. The testing apparatus as claimed in claim **1**, wherein said second current is lower than said first current.

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